POST-FLIGHT INSTRUMENT PROCESSING

Following the return of STS 86, the MEEP container housing ODC was removed from the shuttle's cargo bay at KSC, triple-bagged in a class 10,000 clean room, placed into a dedicated shipping container, and shipped to JSC, where it was received on October 10, 1997. After uncrating and removal of the outermost bag, the container was transferred to the Facility for the Optical Inspection of Large Surfaces (FOILS) laboratory where it was opened and disassembled. The FOILS laboratory is a class 10,000 clean room that contains two major work areas for the processing, inspection, and documentation of exposed flight hardware: (a) a class 1,000 flow bench and (b) an automated scanning platform. This platform is equipped with an optical microscope and a high-resolution CCD camera that are controlled by a dedicated PC computer (see below). Note that all aerogel collectors are being processed and stored in the FOILS lab for the duration ODC's analysis phase (*i.e.*, ~ 2 - 3 years).

After removing the remaining two protective bags, the exterior of the MEEP container, built from aluminum (6061-T6), was closely inspected for the presence of impact and/or contamination features. In general, the MEEP container was relatively clean and pristine, both exterior and interior surfaces, with only modest, honey colored staining in several exterior areas, akin to some of the LDEF surfaces, although much less pronounced than on LDEF. A total of nine hypervelocity craters, all < 500 µm in diameter, were found on the exposed MEEP container surfaces. Following the inspection of the exterior surfaces, the container was opened as shown in Figures 5 and 6. All aerogel tiles were firmly in place and, all but one were exceptionally pristine in appearance, attesting to aerogel's space worthiness and to highly successful EVA operations by the STS 76 and STS 86 crews, respectively. A number of large impact features and penetration tracks were readily apparent upon opening of the MEEP container. Figure 6 shows the first images taken of the full trays, in their most pristine state, acquired immediately after opening of the MEEP container. Figure 6 also illustrates the identification system we employed for individual tiles via letters (vertical columns) and numbers (horizontal rows). Note that the MEEP half containing the mounting bracket (substantially cropped, middle of left side) is arbitrarily defined as Tray 1, while the Tray 2 half possessed the handle, seen on the right side of Figure 6.

Figure 5. Opening of the MEEP container in the FOILS Laboratory at JSC. Ram-pointing Tray 1 (foreground) rests on the table, while the wake-pointing Tray 2 (recognized by the handle bars) is rotated into a nearly vertical position.

The in-flight orientation of each tile was preserved, with respect to the MEEP container, by the placement of a small silver dot, from a paint pen, in the lower left-hand corner of each tile. This mark served to orient the individual tiles during the ensuing investigations, with the marked corner representing the (0,0) origin of the X (horizontal) and Y (vertical) axes, permitting each impact feature to be recorded within tray-specific coordinates, which could be transferred to Mir, and ultimately to a geocentric frame of reference.

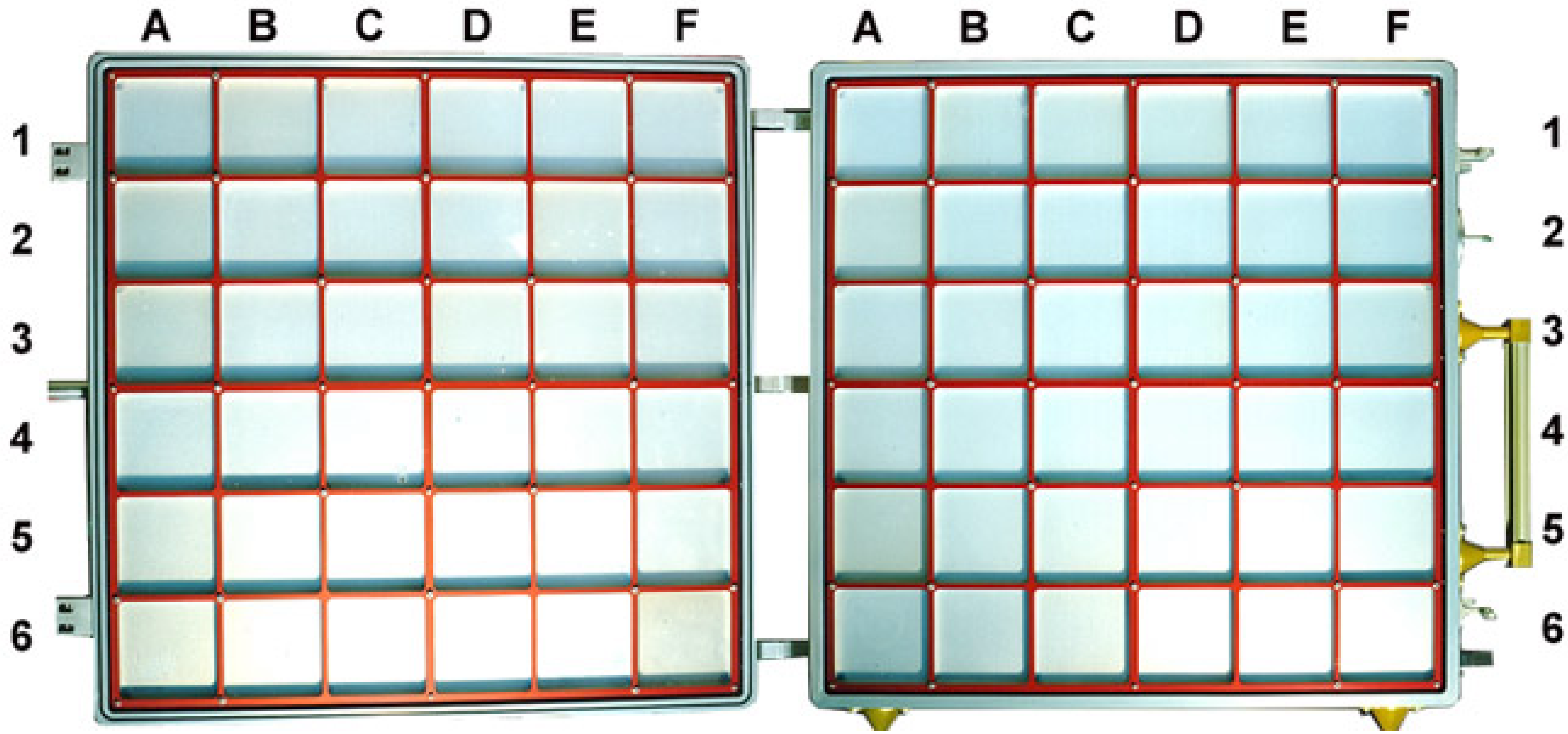

Figure 6. Close-up photograph of the opened ODC experiment and individual aerogel tiles, each ~ 10 X 10 cm. Horizontal rows were assigned letters A - F (starting on left), while vertical columns were labeled 1 - 6. The two largest impact features on ODC can be seen towards the bottom of tile C04 (Tray 1) and on the extreme right-hand side of the Hold-Down Grid of cell B01 (Tray 2).

Figure 7. Installation of plexiglass covers that protected the aerogel collectors during most of the disassembly sequence. The covers contained access holes to all critical fasteners below.

Following the initial photo-documentation of the opened MEEP container, a protective, transparent plexiglas cover was installed over the exposed surfaces (Figure 7); this cover plate possessed small holes that allowed access to screws that were critical to the continued disassembly of the collectors. By unscrewing the standoff fasteners, each collector could be removed as a unit from the MEEP container to be placed onto a dedicated support structure inside the class 1,000 flow bench for further disassembly. The support structure held the assembly frame from the side for easy removal of the Hold-Down Grid (Figure 8) and Interface Plate, being held together by bolts that could be unscrewed from the top. No tiles fell out of the Assembly Frame as the Interface Plate was removed and lowered ~ 15 mm to the surface of the flow bench. At this point, the fully loaded frame was essentially free floating and merely supported at its periphery (Figure 9). Individual tiles could now be pushed downward with a plunger-like tool to land on the Interface Plate after an ~ 3 cm free fall.

Figure 8. Removal of the protective plexiglas cover and Hold-Down Grid in class 1000 flow bench of the FOILS laboratory.

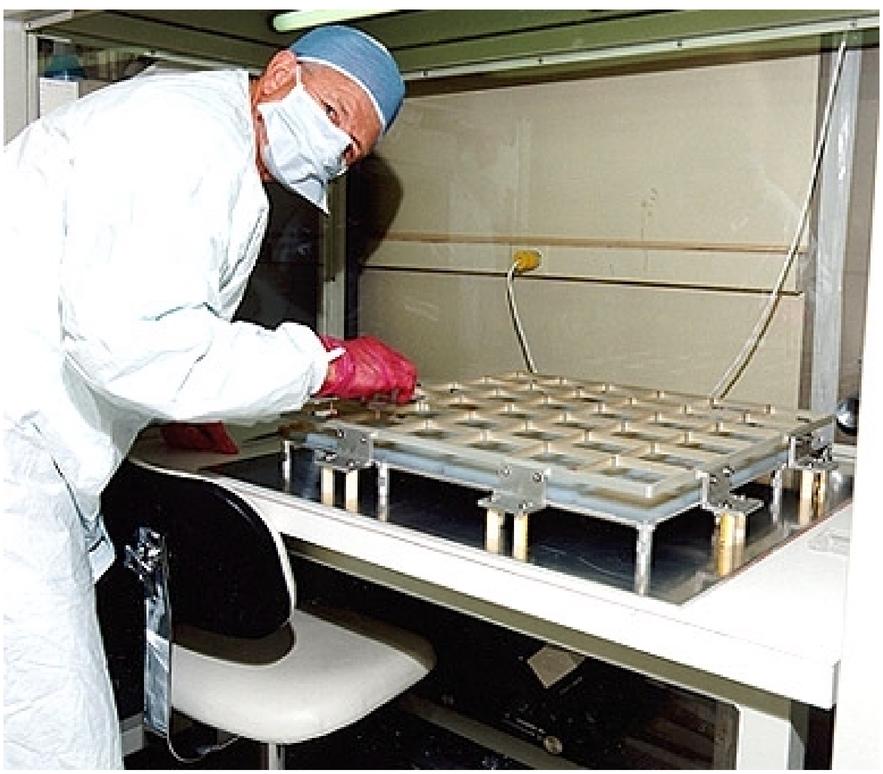

Figure 9. Freestanding Assembly Frame immediately following the removal the aerogel tiles using a flexible plunger tool. The tiles dropped ~ 3 cm and came to rest on the tray's Interface Plate.

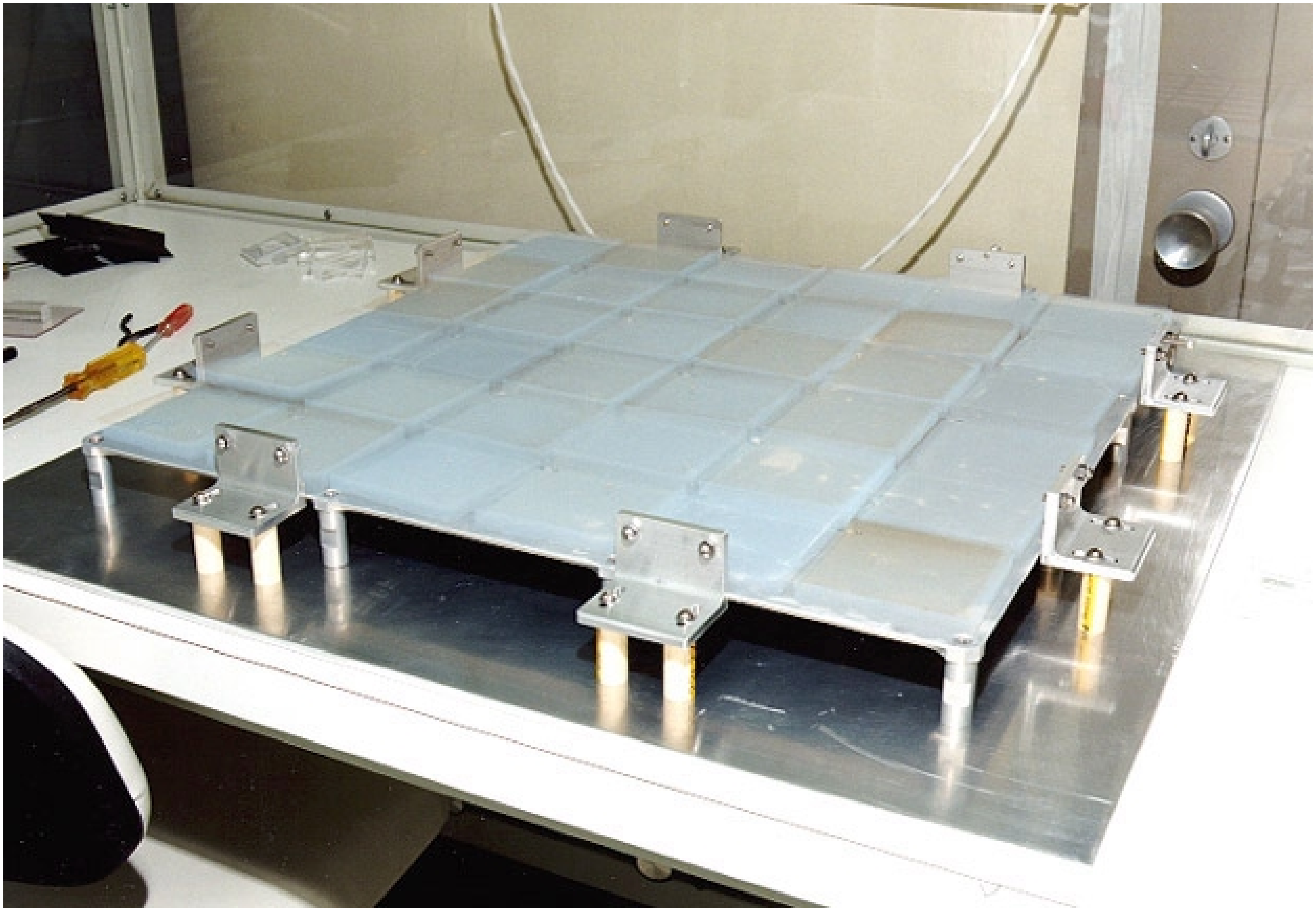

Figure 10. Complete array of harvested tiles, from ODC Tray 1, resting on the Interface Plate with their original flight orientations preserved. Note the distinct coloration of some tiles and the dramatic color contrasts of neighboring tiles, suggesting that the coloration relates to some intrinsic tile property, and not to some depositional processes of a (gaseous?) contaminant.

All tiles were dislodged from their respective frames during a single session, initially residing on the Interface Plate with their relative flight configurations completely preserved as seen in Figure 10. Note that individual tiles varied in color exhibiting shades of tan to brown. This coloration was not present in the tiles prior to flight and seems to be unrelated to the deposition of surface contaminants, since the color varies abruptly from tile to tile with specific color being relatively uniform for any given tile. The discoloration resulted from exposure to space; specific mechanisms that cause this tanning remain unexplored, yet we suspect that oxidation of organic contaminants was involved that apparently varied in concentration from tile to tile. As shown in Figures 11 and 12, individual tiles were then removed from the Interface Plate and transferred into clear, pre-labeled storage containers. In general, the aerogel was handled best by placing it carefully onto a stout sheet of paper, preferably black for maximum contrast and ease of seeing and tracking the transparent materials. Tray 1 was completely processed and harvested in this manner before Tray 2 was removed from the MEEP container and processed in an identical manner.

Figure 11. Transfer of the ODC aerogel collectors into individual plastic containers.

Following harvesting, each individual tile was photo-documented, presumably in its most pristine state, using high-resolution optical (Hasselblad) photography, referred to as *mug-shots*. Examples of this optical photography can be seen in Figures 13 and 14, and a systematic compilation of all mug shots is presented as Appendix A of this report. All mug-shot photographs contain the tile identifier (*e.g.*, 2B01 in the top legend; tray [1 or 2], column [A-F], row [01-06]) and are oriented such that the (0,0) coordinates are in the lower left-hand corner. Although the fairly translucent nature of aerogel makes it a difficult material to photograph, some of the larger impact features (> 1 mm) are readily recognized in Figures 13 and 14; many features << 1 mm are can be seen as well. Tile 2B01 (Figure 13) is unusual in the sense that it suffered not only the largest impact event of ODC (right-hand side), which was affected/terminated by the frame edge, but it also contains many additional features > 2 - 3 mm in size. Figure 14 is more typical of the majority of the ODC tiles, displaying only two large events; a few tiles contain no impact feature > 1 mm in diameter. We used these mug shots extensively during the optical scanning operations and during the preparation of SEM samples, documenting the physical splitting and subdividing of the pristine parent tiles.

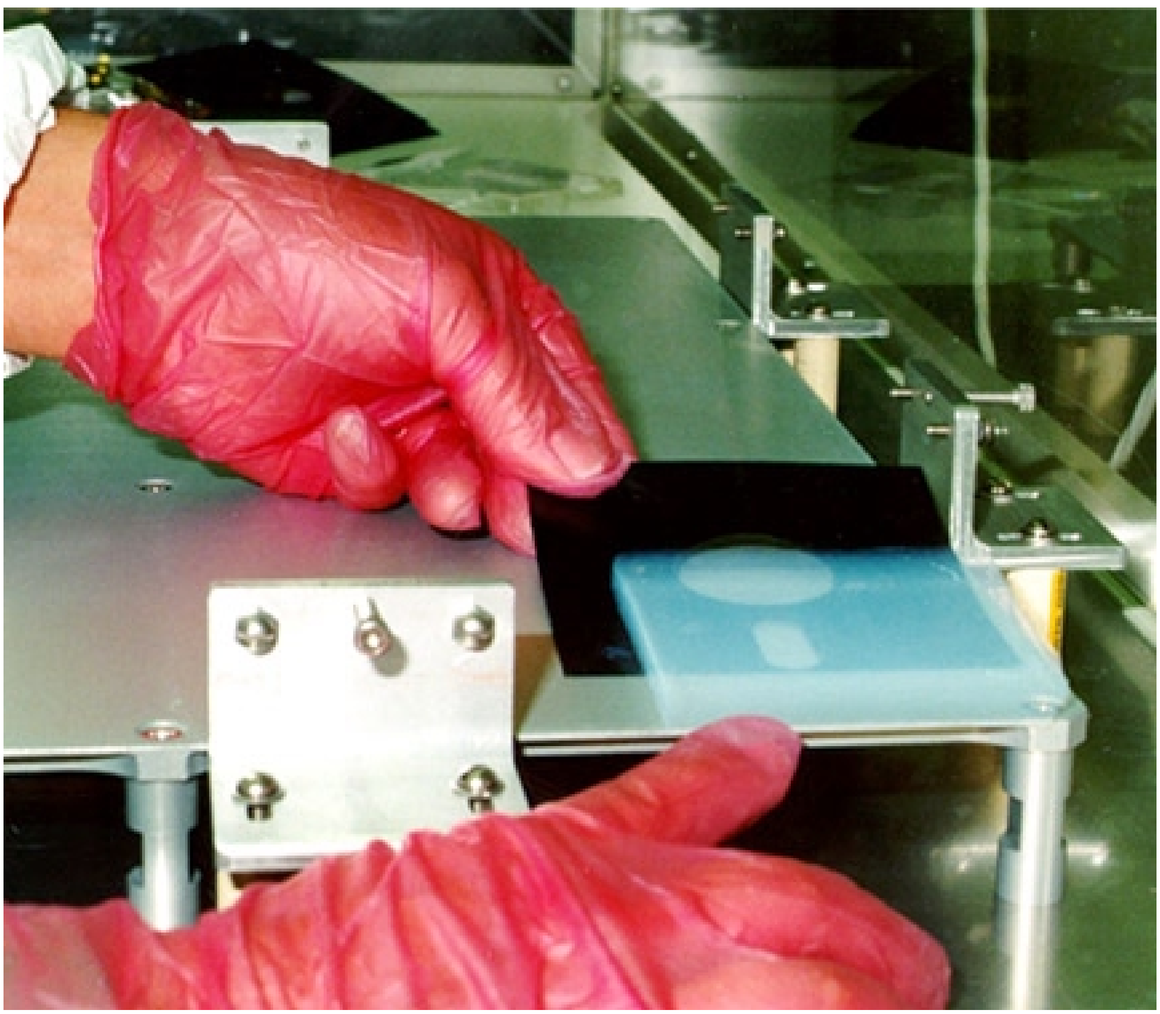

Figure 12. Detail of the aerogel harvesting and handling procedures illustrating the use of a flexible spatula-like device to pick up the tiles. Also visible in this image is a detail of the device that supported the ODC Assembly Frame.

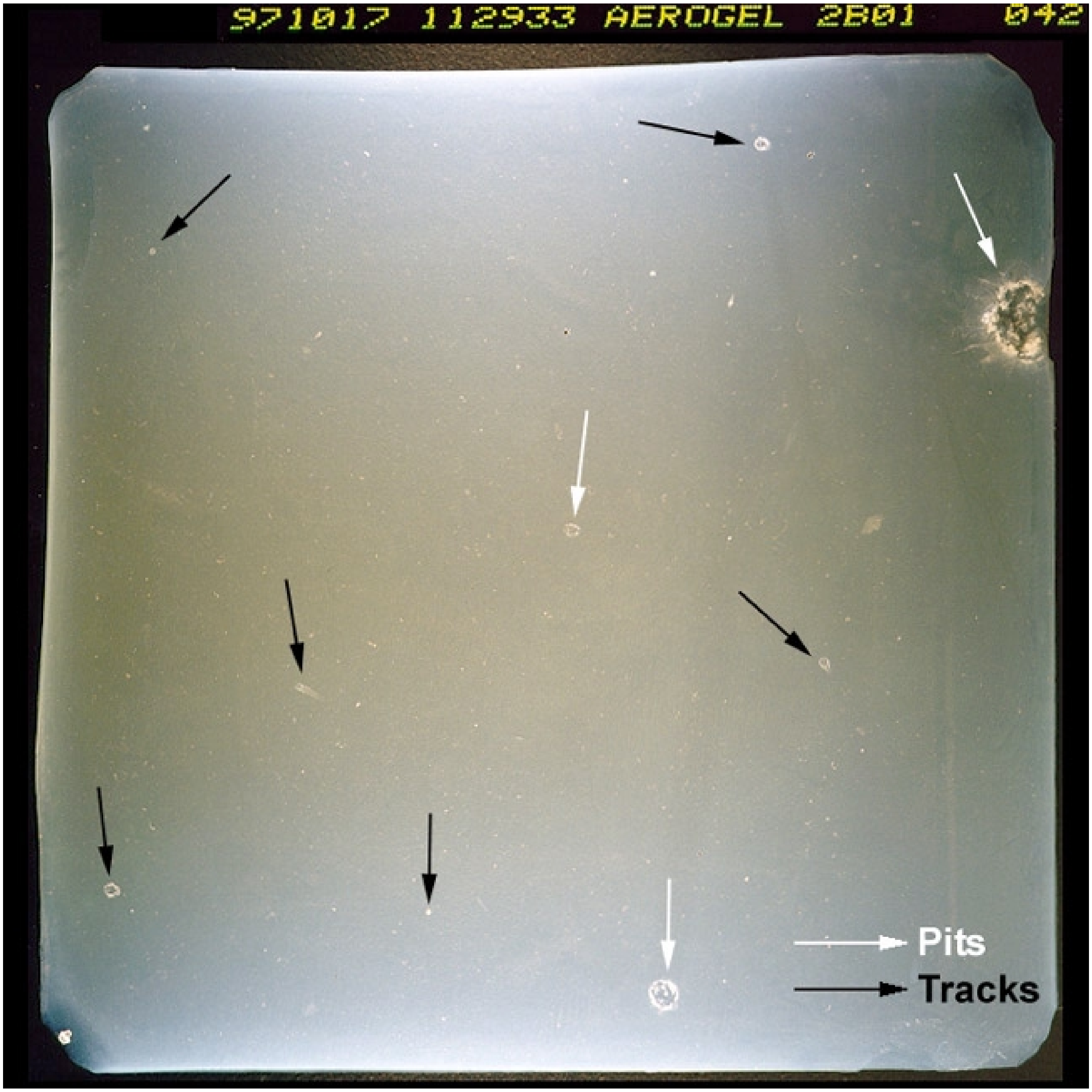

Figure 13. Representative "mug shot" of an individual aerogel tile (~ 10 cm square) showing that optical photography posesses adequate resolution to resolve impact features at scales of < 1 mm. The actual tile (2B01) shown contains an unusually high number of impact features > 1 mm, including circular pits (white arrows) and tracks of various lengths (black arrows). This tile also contains the largest impact feature observed on ODC, an ~ 9 mm pit that was truncated by the Assembly Frame (far right).